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Carbon Monoxide in Public Gas Supplies

MORE than ordinary interest is attached to the Report before us,[1] inasmuch as it deals with issues of considerable importance from the points of view both of national economy and of public health. To understand the question involves not only some knowledge of the history and conditions of public gas supplies during the past century, but also a right perspective in our views as to the most economical solution of the domestic smoke problem.

For nearly eighty years after the establishment of the first public gas-works in London in the year 1813, the gas undertakings in Great Britain supplied their customers with what has been called a "straight coal-gas," or, in other words, with a gas obtained by the carbonisation of a bituminous coal (sometimes mixed with a small proportion of "cannel-coal") in retorts. In the early days of the industry, cast-iron retorts were employed, necessitating the use of comparatively low temperatures (650–750° C.) and the production of a rich lighting gas and a "soft" coke, which latter could be utilised effectively in domestic fire-places. It is significant that the name of the first London gas undertaking was the Gas Light and Coke Company, and that Frederick Accum, who in 1819 wrote the first descriptive treatise on the manufacture of coal-gas, was able to say that "the demand for coke in the capital, since the establishment of the gas-light works, has prodigiously increased. Numerous taverns, offices, and public establishments which heretofore burnt coal, now use coke to the total exclusion of coal; and in every manufactory which requires extensive lighting or heating, gas and coke are now the means jointly employed." It would thus appear that, a century ago, the London gas undertakings, by their enforced practice of carbonising coal at moderately low temperatures, supplied the public with two "smokeless" coal products, namely, gas for lighting and a soft coke for heating purposes, the *combined* use of which made possible the abandonment of the burning of raw coal in houses, offices, and public establishments.

As time went on, however, cast-iron retorts were replaced by those of fireclay in the gas-works, with the natural result that higher carbonising temperatures were employed. But even fifty years ago, when this change had become universal, the chief object of the gas undertakings still remained the production of a coal-gas of high self-illuminating power together with a coke of such "medium" porosity and texture that it would answer most domestic fuel requirements. The coal-gas of fifty years ago would probably contain (about) 0·25 per cent. of CO_2, 6·0 of CO, 5·0 of "heavy hydrocarbons," 40·0 of methane, 45·0 of hydrogen, and 3·75 of nitrogen, and its gross calorific value would be (about) 700 B.Th.U. per cb.ft., measured *dry*, at 60° F. and 30 in. barometric pressure.

With the rapid development, from 1890 onwards, of incandescent mantle gas lighting, which followed close upon A. von Welsbach's inventions in Germany (1885–95), and the concurrent increasing use of gas for cooking and domestic heating purposes, which were the outcome of Thomas Fletcher's pioneering efforts in this country, the need of a rich gas of high self-illuminating power diminished, and eventually almost disappeared. The demand arose for a cheaper gas of medium illuminating (say of 15–17 candle-power) but good heating power (say of about 600 B.Th.U. gross per cb.ft. at 60° F. and 30 in. barometric pressure). This led to raising the carbonising temperature in the retorts up to 1000° C. or more, and using "regenerative" methods of firing the retort settings, whereby some 12,000 cb.ft. of gas per ton of coal were produced, containing about 2·5 per cent. of CO_2, 6·0 of CO, 3·5 of heavy hydrocarbons, 33·0 of CH_4, 5·0 of H_2, and 5·0 of N_2, and having a *gross* calorific value up to about 600 B.Th.U. per cb.ft. at 60° F. and

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[1] Gas Regulation Act, 1920. Report to the Board of Trade of the Departmental Committee on Carbon Monoxide. Pp. 12. (Cmd. 1422.) (London: H.M. Stationery Office, 1921.) 1*d.* net.

30 in. barometric pressure. As the carbonising temperature increased, however, the residual coke became gradually harder, and therefore less suitable for domestic consumption, especially in an open fire-place with low draught. Indeed the gas undertakings soon found themselves in the position of producing a coke which was neither a good domestic fuel nor yet a high-class, hard metallurgical coke, with the result that its profitable disposal was often a matter of difficulty.

An obvious way out was to convert part of the coke into "water-gas," by one or other of the processes which had been developed since the first Lowe plant had been installed in Great Britain at the Leeds Forge in the year 1888. And by mixing some water-gas with the coal-gas, a larger proportion of the potential heat-units in the coal taken into the gas-works could be sent out in the form of gas. Moreover, water-gas is cheaper to produce, and has an even higher calorific intensity (flame temperature), although the thermal efficiency of its production is somewhat lower, than that of coal-gas. Another important advantage about water-gas is that the plant for producing it occupies a much smaller area than a coal-carbonising plant for equal gas-therm yields; and, moreover, its operation is so comparatively easy and labour-saving that, to the harassed gas engineer, it is "a very present help in time of trouble," *e.g.* when coal supplies are unduly short or the demands of labour excessive. Up to the outbreak of the war, however, British gas undertakings had been commendably chary in using water-gas; indeed, it is probable that in the year 1913 the proportion of water-gas sent out did not, on the average, exceed (if it was as much as) 15 per cent. of the whole gas output of the works. The public would, in that year, be supplied with a gas of an average gross calorific value of about 575 B.Th.U. per cb.ft. at 60° F. and 30 in. pressure, of which the content of carbon monoxide did not exceed 15 per cent. at the most, and more probably in the majority of cases would not be greater than 10 per cent.

It may here be mentioned that in the United States, where the manufacture of water-gas originated in 1885, the policy of converting the coke into water-gas and of carburetting the latter with oil-gas had, long before the war, been pushed almost to its extreme limits. Thus New York had long been supplied with a mixture of about one part of "coal-gas" with as much as six or seven parts of "carburetted water-gas"; Chicago with a mixture of one to five parts; Boston with a mixture of equal volumes, and so on. In 1917, the New York gas contained, on an average, about 3·0 per cent. of CO_2, 27·0 of CO, 12·5 of heavy hydrocarbons, 20·0 of methane, 30·0 of hydrogen, and 7·5 of nitrogen; and its average calorific value would probably be about 675 B.Th.U. per cb.ft. at 60° F. and 30 in. barometric pressure.

During the war circumstances arose which fully justified, as a temporary measure, the relaxation of some of the conditions formerly imposed upon British gas undertakings, which were permitted to supply gas of much lower calorific value and higher water-gas content than in pre-war days. In the circumstances this could not well be helped, and it was endured by consumers without complaint as a war necessity. Unfortunately, however, the gas industry, having thus been liberated temporarily from former controls and restrictions, yearned for a more permanent emancipation therefrom; and so what may be termed a strong "life and liberty" movement set in, more particularly in the direction of supplying gas of lower calorific value, on the plea of benefiting the consumer by giving him cheaper gas-therms than otherwise he could obtain.

At this point the Fuel Research Board stepped in, at the request of the Board of Trade, with the object of advising "what is the most suitable composition and quality of gas and the minimum pressure at which it should be generally supplied, having regard to the desirability of economy in the use of coal, the adequate recovery of by-products, and the purposes for which gas is now used." The answer of the Fuel Research Board to the prevailing view in the gas industry "that the elasticity in manufacture can best be secured by the fixing of a sufficiently low calorific standard" was somewhat vague and hesitating; but the Board rightly based its recommendations upon the principle that "the interests of the consumers can best be conserved if their contract with the gas undertaking is based on the sale and purchase of heat energy measured in fixed units which can be scientifically determined by simple means." And it was therefore proposed that "the consumer should be charged for the thermal units which he actually receives in the same way as the consumer of electricity is charged for the Board of Trade units which pass through his meter." This important conclusion was, however, accompanied by a pronouncement that "the natural diluent for coal-gas is water-gas"; and the Board finally recommended that, subject to the foregoing principle, the gas undertakings should be "free to deliver to the consumer any mixture of the ordinary combustible gases free from sulphuretted hydrogen and not containing more than 12 per cent. of inert constituents," whilst suggesting "the standardisation of burners in appliances for a limited number of calorific values" between 400 and 500 B.Th.U. per cb.ft. The Board's main recommendations, except as regards inert constituents, were given effect to by the Gas Regulation Act of 1920, which also provided (*inter alia*) that the Board of Trade shall, as soon as may be after the passing of this Act, cause an inquiry to be held into the question whether it is necessary or desirable to prescribe any limitations of the proportion of carbon monoxide which may be supplied in gas used for domestic purposes.

Now, whilst it is generally admitted that there are certain economic advantages to be gained by supplying the public with coal-gas diluted with water-gas, there are, nevertheless, weighty objections to an *unlimited* proportion of the latter being allowed in a domestic gas supply, arising from the poisonous nature of carbon monoxide (of which water-gas contains about 42 per cent., as against, say, 7 per cent. in coal-gas), and also from the fact that the range of explosibility of water-gas–air mixtures is considerably wider than that of coal-gas–air mixtures. Any *large* admixture of water-gas with coal-gas in a domestic supply would add materially to the dangers both of carbon monoxide poisoning and of gas explosions in houses.

The dangers of carbon monoxide poisoning with gas containing a large proportion of water-gas formed the subject of an official inquiry by a Committee (of which Dr. J. S. Haldane and the late Sir William Ramsay were members) appointed by the Home Office, whose Report (Cmd. 9164) was issued in the year 1899. This Committee considered that the most probable manner in which accidental death from gas poisoning would occur would be from gas, inhaled during sleep, escaping from a burner left full on unlighted; and, influenced by experiments made by Dr. Haldane, as well as by detailed information laid before them as to the uses of water-gas in the United States and its effect upon human health, and having in mind also the nature of carbonic oxide poisoning and the faulty character of gas pipes and fittings in the poorer class of house, the Committee reported that "the most direct, and in our opinion, the only effective method of preventing danger from water-gas is to fix a limit which the carbonic oxide in a public and domestic gas supply shall not, in ordinary circumstances, exceed." And, whilst admitting the difficulty of assigning a limit applicable in all circumstances, they suggested that 12 per cent. of carbonic oxide would in ordinary circumstances be a proper limit, with 20 per cent. as the highest that should ever be allowed, and that "only under special circumstances." Since this Committee reported there has probably been some (though not a great) improvement in the character of the gas service-pipes and fittings in the poorer class of houses. Also the more extended use of incandescent mantle lighting has undoubtedly meant that less gas (in the ratio of, say, 7 to 10) would nowadays escape into a bedroom, from a burner left full on unlighted, than twenty years ago. Therefore, if in 1899 somewhere between 12 and 16 per cent. of carbonic oxide was considered to be, "in ordinary circumstances," a proper limit, it would follow (the poisonous nature of carbonic oxide remaining unchanged) that to-day 20 per cent. might similarly be considered a reasonable maximum limit. This last-mentioned view was taken by the British Association Fuel Economy Committee in its Second and Third Reports (1919 and 1920), and afterwards supported, on physiological grounds, by Dr. J. S. Haldane in his evidence before the Board of Trade Committee. The adoption of such a limit would mean that the gas undertakings would be at liberty to supply a mixture of one hundred parts of straight coal-gas with (up to) fifty parts of blue water-gas, a fairly generous allowance of the last-named.

But the gas industry is to-day much more strongly organised and entrenched than it was twenty years ago. So, whilst admitting that few undertakings would be inconvenienced by a limit of 20 per cent. of carbonic oxide, except in cases of emergency, and disclaiming any present intention of supplying very high percentages of water-gas (in London a proportion of only $33\frac{1}{3}$ per cent. of carburetted water-gas being contemplated), its advocates argued before the Board of Trade Committee that the advantages of cheaper gas (although nowadays gas, at twelve to fifteen pence per therm, seems a very dear fuel) outweigh the danger to human life feared from higher proportions of carbon monoxide, and, therefore, that no statutory limitation should be imposed. Eventually, as the result of its inquiry, the Committee did so decide, being "greatly impressed by the necessity of allowing the development of the gas industry to proceed, without any check on its natural progress."

Such was the Committee's conclusion on the matter, but it was qualified by the suggestion "that the Departments concerned should carefully watch the situation so that, if the freedom from limitation which we recommend is accompanied by unexpectedly unfavourable results, the attention of Parliament may, if necessary, be again directed to the matter," as though the Committee had still some misgivings about its verdict and did not consider it as final. Certainly, in the light of statistics relating to accidental gas poisoning placed before the Committee by the Registrar-General's Department, and those published for the years 1914–19 by the Gas and Electric Light Commissioner of Massachusetts, which are referred to in the Report, there would appear to be a much greater risk of accidental death from carbon monoxide poisoning in localities where coal-gas largely diluted with water-gas is supplied than in those in which no water-gas is added. Indeed, it seems arguable that, had the matter been decided mainly by such statistics, and on the physiological evidence, rather than on those of the cheaper production of gas, a verdict in favour of limitation would have been the more natural and appropriate one.

There is admittedly much to be said on hygienic grounds in support of the argument for cheaper gas, especially in view of the great improvements made during recent years in gas fires, and their consequent wider adoption for the heating of living rooms which are in use for part of the day only. For such purposes, as well as for cooking, gas is still an economical fuel, not so much on grounds of its initial cheapness (for it is a relatively dear fuel as compared with coal), as on those of convenience and cleanliness. It may, however, be argued perhaps with even greater force that, for the ordinary living rooms of a house, which require to be heated all day long, there is probably nothing more healthy and economical than radiation from red hot semi-carbonised coke burning in an open fireplace, and that it is in such direction, rather than that of gas heating, that the ultimate solution of the domestic smoke nuisance mainly lies, although undoubtedly each method will contribute to the desired end.

The Committee does not appear to have considered at all the question of the greater risks of back-firing and explosions arising out of the much wider range of explosibility of coal-gas when largely diluted with water-gas for a domestic supply, although this is a matter of some importance. Moreover, it seems to have been overlooked that whereas the gas supply of many American cities may contain as much as 25 to 30 per cent. of carbon monoxide, yet it would be of a much higher calorific standard (*vide* that of New York) than any gas supplied, or likely to be supplied, under the new regulation by British undertakings. Indeed, it is a matter of mere arithmetic that an American burner supplied with gas of 675 B.Th.U. per cb. ft., and containing 27 per cent. of carbon monoxide, would, for a given heat development in the flame, actually pass somewhat less carbon monoxide in a given time than a British burner supplied with a 475 B.Th.U. gas containing only 20 per cent. of carbon monoxide. It may, however, be hoped that British gas undertakings will, in their own interests, voluntarily work within such a 20 per cent. limit, and that gas consumers generally will fully realise the importance of keeping a sharp look-out for gas leakages and of using only the best-made taps and fittings.

W. A. B.

Diseases of the Rubber Tree (Hevea braziliensis).

The Diseases and Pests of the Rubber Tree. By T. Petch. Pp. x+278+6 plates. (London: Macmillan and Co., Ltd., 1921.) 20*s.* net.

THE growth of the rubber plantation business, in which many millions sterling of British capital are invested, provides a striking example of the advantages that accrue from the combination of science and industry. It is, indeed, not too much to say that but for this combination the rubber planting industry, as it has flourished during the last ten years or more, could scarcely have maintained its existence.

It is not necessary to direct attention to the essential aid which science has given in enabling the raw rubber to be fitted for its various commercial applications. On the other hand, the present extensive development of rubber in industry would not have been possible had not scientific help been at hand to enable the plantations themselves to be maintained. In the earlier days, as in many another tropical agricultural industry, all went very well with the planter—and then came the inevitable onset of disease, which under tropical conditions of growth may, and if unchecked will, easily assume serious proportions. The first serious check in the history of the plantation enterprise came in the form of a root